U. S. FOREST SERVICE

RESEARCH NOTE NC-65

NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE

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A COMPUTER PROGRAM TO EVALUATE TIMBER PRODUCTION INVESTMENTS UNDER UNCERTAINTY

ABSTRACT.—A computer program has been written in Fortran IV to calculate probability distributions of present worths of investments in timber production. Inputs can include both point and probabilistic estimates of future costs, prices, and yields. Distributions of rates of return can also be constructed.

Several computer programs designed to evaluate investments in timber production are now generally available.[1] Each requires that point estimates of costs, prices, and physical yields be provided as inputs. Present worths and, perhaps, internal rates of return are then calculated. This Note describes a new computer program that generates probability distributions of present worths from combinations of point and probabilistic estimates that define investments in timber production.

At the beginning of an investment period, a forecast of a cost or income is subject to error. The likely extent of that error can be quantified by substituting several possible values for the usual point estimate. For example, if low, most likely, and high estimates of the future market price for pulpwood are made, a mathematical function consistent with these estimates can be constructed. In the NCSUBPR (*N*orth *C*entral *SUB*jective *PR*obabilities) computer program, beta probability distributions are fit to multiple-valued estimates of this type.[2]

Annual payments, one-time or nonrecurring payments, and prices (for as many as nine products) can be entered into the program either as point estimates or as low, most likely, high estimates. Physical yields, which can be separately specified for intermediate and final harvests, can be entered either as point estimates or as normally distributed variables. In the latter case, the standard deviation is entered as a proportion of the yield. (This value might be taken from experimental work or subjectively estimated, say, as one-sixth the range of likely yields.) Several discount rates and rotation lengths can also be specified if repeated analyses of a single set of input data are desired.

[1] *For example, Dennis L. Schweitzer, Allen L. Lundgren, and Robert F. Wambach. A computer program for evaluating long-term forestry investments. U.S.D.A. Forest Serv. Res. Pap. NC-10, 34 p., illus. N. Cent. Forest Exp. Sta., St. Paul, 1967; and Clark Row. Determining forest investment rates-of-return by electronic computer. U.S.D.A. Forest Serv. Res. Pap. SO-6, 13 p., illus. S. Forest Exp. Sta., New Orleans, 1963.*

[2] *Letting L and H represent the low and high estimates and A and B two mathematical parameters, the beta probability distribution can be written as*

$$Prob(x) = \frac{(A+B+1)!}{A!\ B!}\ (x\text{-}L)^{A}\ \ (H\text{-}x)^{B}$$

See page 129 in Alexander M. Mood and Franklin A. Graybill. Introduction to the theory of statistics (2nd ed.) 443 p., illus. McGraw-Hill, 1963.

We can illustrate the use of the NCSUBPR program with the problem of deciding whether oak sawtimber or pulpwood on a 40-year rotation is a better investment. When the input data (table 1) are entered into the computer, each multiple-valued estimate is associated with either a beta or normal distribution. Then a variant of the Monte Carlo technique is used to combine these individual distributions with the point estimate of annual costs into a cumulative probability distribution of present worth for one rotation (table 2). This measure of desirability of an investment summarizes all of the estimates of future costs, prices, and yields. If they are imprecisely estimated, as in the present example, the distribution will reflect the odds that each of several values of present worth is correct.

After a separate estimate of present worth for each alternative has been generated, the data can be plotted (fig. 1). If a 3 percent discount rate were appropriate, we might conclude that sawtimber should be produced.

Table 1. — *Input data illustrating use of NCSUBPR computer program*

Estimated costs (from expert opinion)		
Annual costs including taxes	$.25/acre	
Initial prescribed burning to encourage sprouting		
Range	$ 5.00 - $20.00/acre	
Most likely	$10.00/acre	
Estimated prices (from price reporting service)		
Pulpwood price		
Range	$.50 - $2.00/cord	
Most likely	$.93/cord	
Sawtimber price		
Range	$5.00 - $12.71/MBM	
Most likely	$9.02/MBM	
Estimated yields (from normal yield tables)		
Product	Yield at age 40	Standard deviation
Pulpwood	30.71 cords	29.4%
Sawtimber	8.60 MBM	47.4%

Table 2. — *Probability distribution of present worth generated by NCSUBPR computer program for producing oak sawtimber on 40-year rotation (discount rate = 3 percent)*

Probability of exceeding present worth	Present worth (dollars)
1.00	- 32.78
.95	- 16.87
.90	- 12.37
.85	- 9.09
.80	- 6.27
.75	- 3.75
.70	- 1.44
.65	.72
.60	2.96
.55	5.03
.50	7.27
.45	9.57
.40	11.77
.35	14.25
.30	16.76
.25	19.60
.20	22.82
.15	26.62
.10	31.30
.05	38.30
.00	70.18

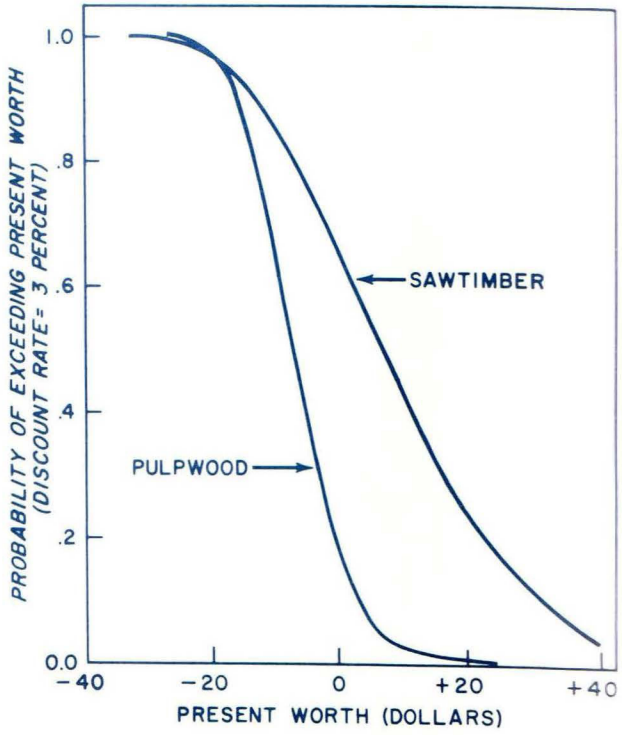

Figure 1. — Probabilities of exceeding specified present worths when producing oak sawtimber and pulpwood in 40-year rotations (discount rate = 3 percent).

The graph suggests there is a 2-in-3 chance of discounted costs at least equalling discounted returns when producing sawtimber. Another way of saying this is that our investment funds have a 2-in-3 chance of earning a 3 percent internal rate of return. If we use the program to evaluate our alternatives at a number of discount rates, each computer run will indicate the chance of achieving a particular rate of return. This approach permitted developing probability distributions of rates of return (fig. 2).

The NCSUBPR program was written in Fortran IV for Control Data Corporation 6400 and 6600 computers. Core storage of 30,000 data words plus compiler requirements and a Fortran compiler capable of utilizing block COMMON, DATA, and DECODE statements are required to run the program. Input is by punched cards and the output is printed. Complete program documentation and a listing of the source deck are available from the North Central Forest Experiment Station.

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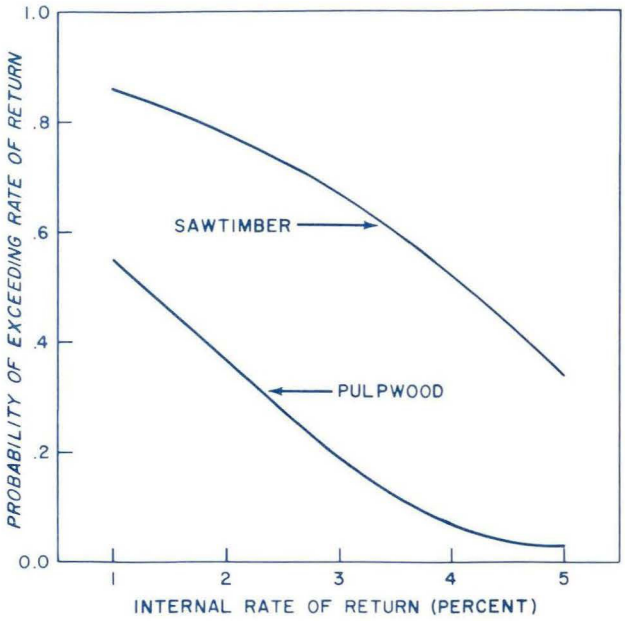

Figure 2. — Probabilities of exceeding specified rates of return when producing oak sawtimber and pulpwood in 40-year rotations.